Cockpit Presentation of Weather Information for General Aviation Airplanes – Part 2

NASA Aviation Safety and Security Program

Weather Accident Prevention Project Review

June 2-4, 2004

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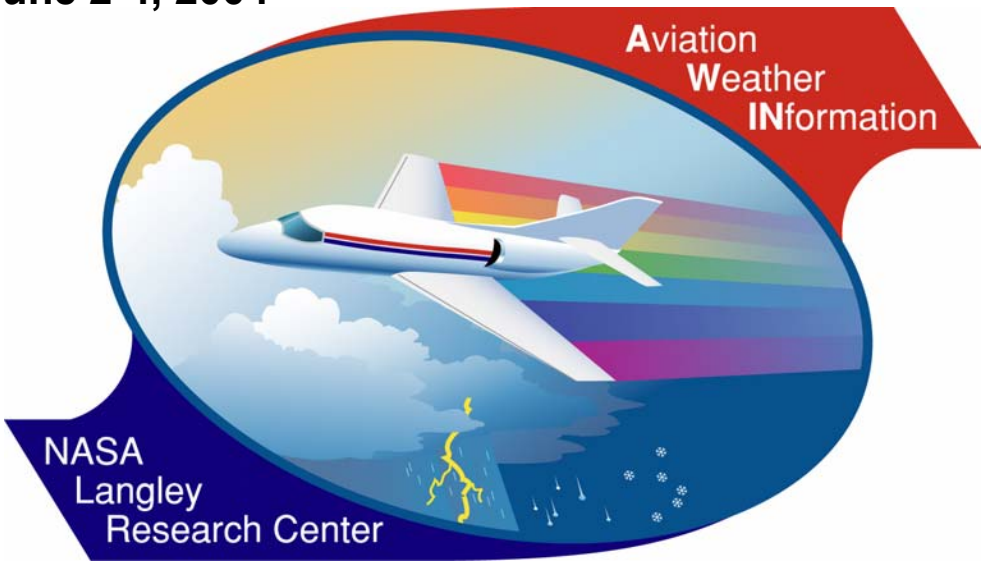

Overview

- Commercial AWIN technology and infrastructure is now in place
- What weather sources and cockpit presentations are most effective? How will pilots use them?
- What design/use guidelines will maximize effectiveness and minimize potential misinterpretation/misuse?
- Numerous AWIN efforts are under way to develop these guidelines

Information, Not Data

Correlation of Radar Reflectivity and Lightning (CoRRaL) Study

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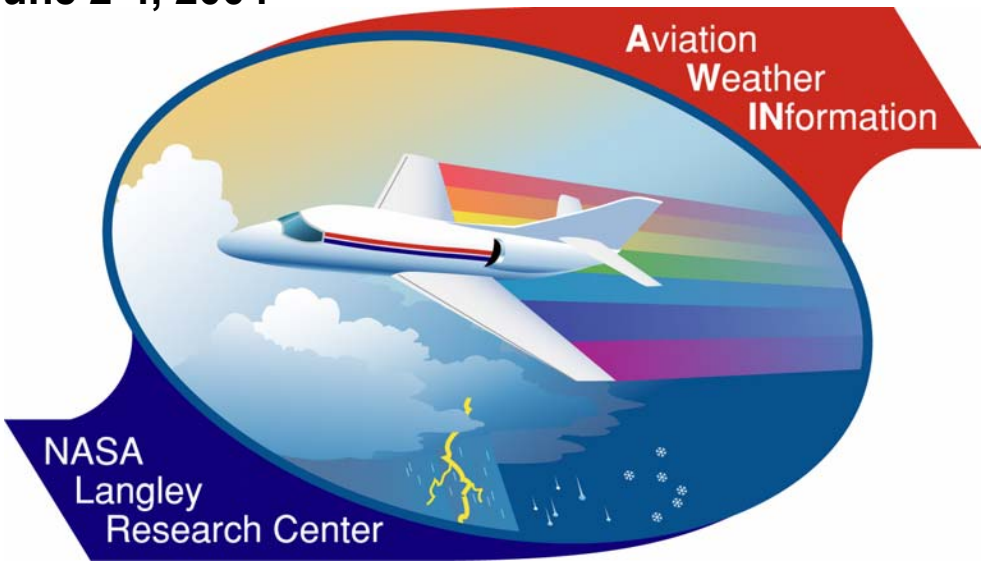


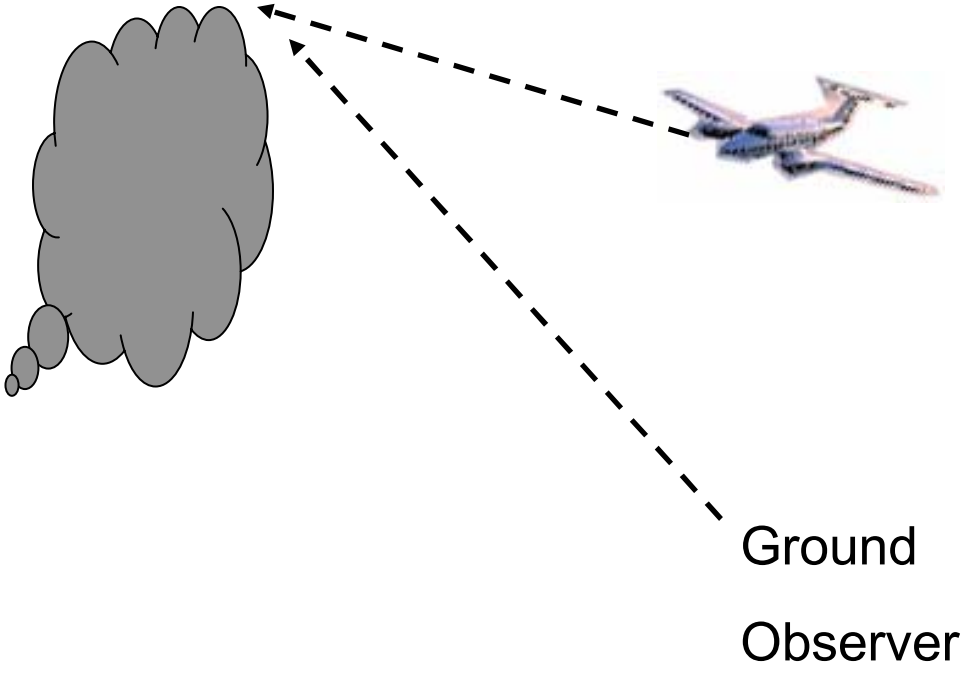
CoRRaL Objectives

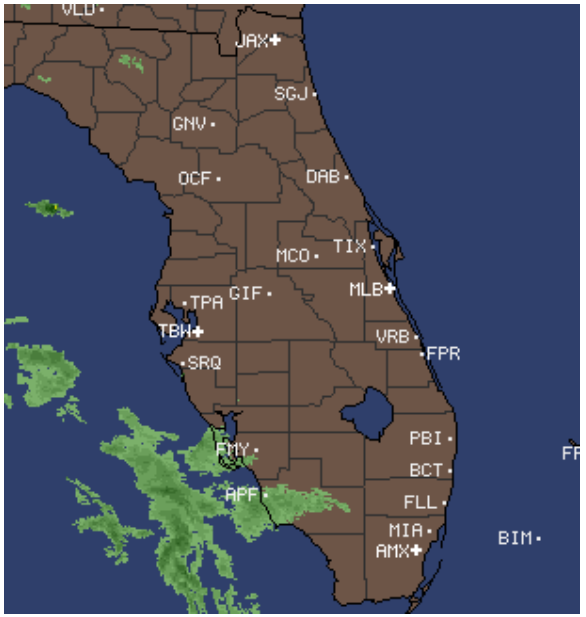
- **Obtain a database of weather information sources for developing airmass thunderstorms**
  - Onboard and ground-based weather radar and lightning detection sources
  - Cloud height and growth rate
- **Use the database to develop AWIN guidelines for:**
  - Datalinked lightning products
  - Improvements to datalinked radar products
  - Composite weather products
  - Pilot use of weather products

CoRRaL Flight Test Scenarios

Aviation Weather Information

- **Approach identifiable airmass towering cumulus/cells using a modified "racetrack" pattern, overhead a ground observer's position**
- **Take ground & airborne azimuth, elevation, and weather source data**





CoRRaL Research Aircraft Panel

Aviation Weather Information

CoRRaL Ground Observer

Aviation Weather Information

CoRRaL Research Airplane at KSC

Aviation Weather Information

CoRRaL Status

- Research flights completed November 2003
- Data analysis is ongoing
  - Numerous challenges
  - "Messy" data
- Weather source comparison results expected September 2004
- Initial product and usage guideline results expected December 2004

Animated NEXRAD Looping Experiments

NASA Aviation Safety and Security Program

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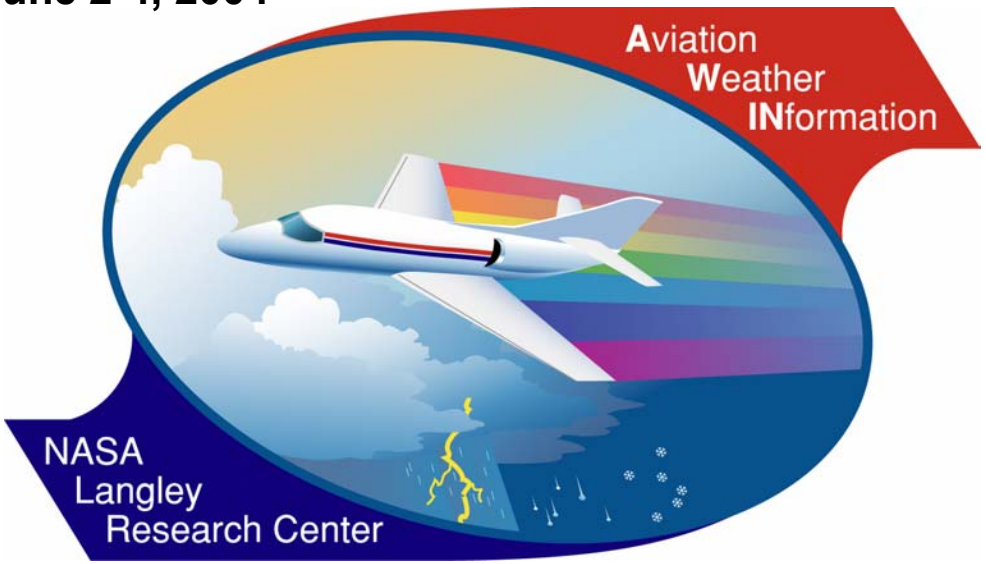


Looping Experiments - Objectives

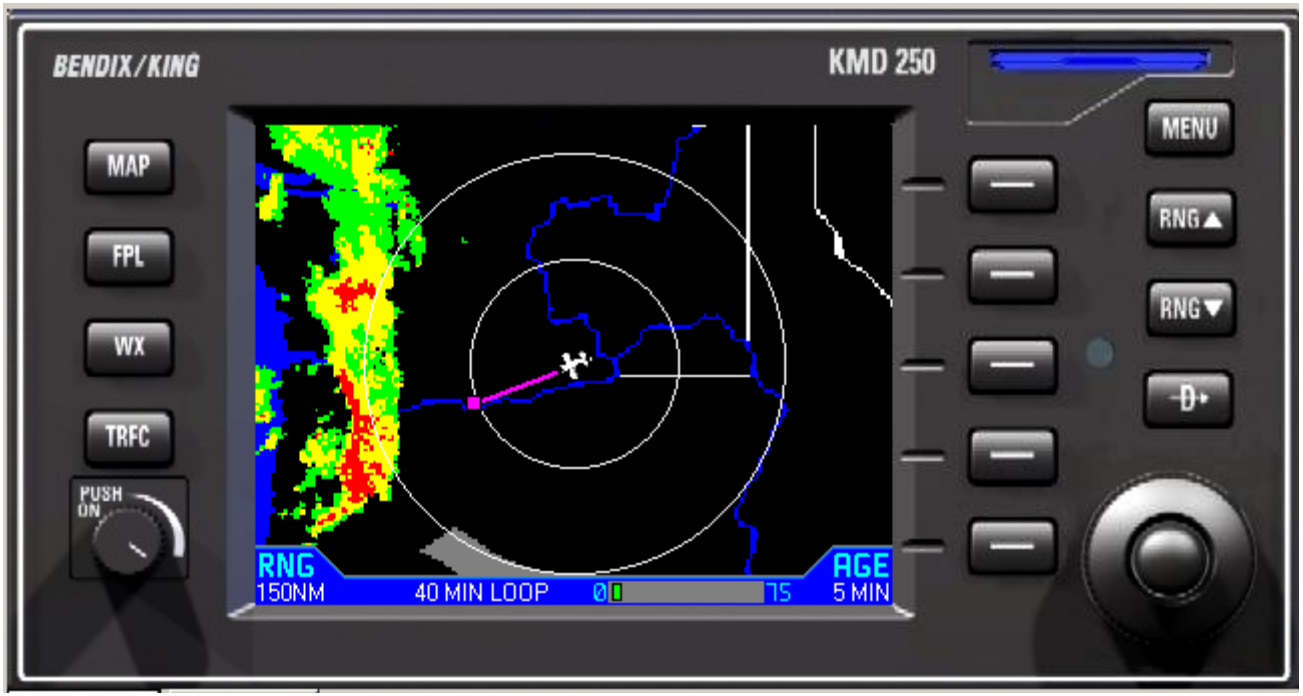
- **Determine optimal presentation parameters for cockpit display of animated NEXRAD imagery**
  - **Limited total and "glance" time available**
  - **Observer's reference frame is moving**
  - **Maximize weather SA, minimize cognitive demands**
- **Determine effectiveness of NEXRAD looping as a weather trending tool**
  - **Comparisons with no-trending baseline**
  - **Comparisons with other trending presentations**
  - **What optimizes weather decision quality as well as SA?**

Looping Experiments - Approach

- Identify relevant independent variables and interactions for looping presentations
- Develop presentation concepts for moving aircraft reference frame
- Design and conduct a family of experiments to determine optimal looping parameters
  - Experiment 1: Different looping parameters, no pilot workload
  - Experiment 2: Optimal looping parameters, with pilot workload
  - Experiment 3: Optimal looping compared to no-looping baseline and other weather trending presentations

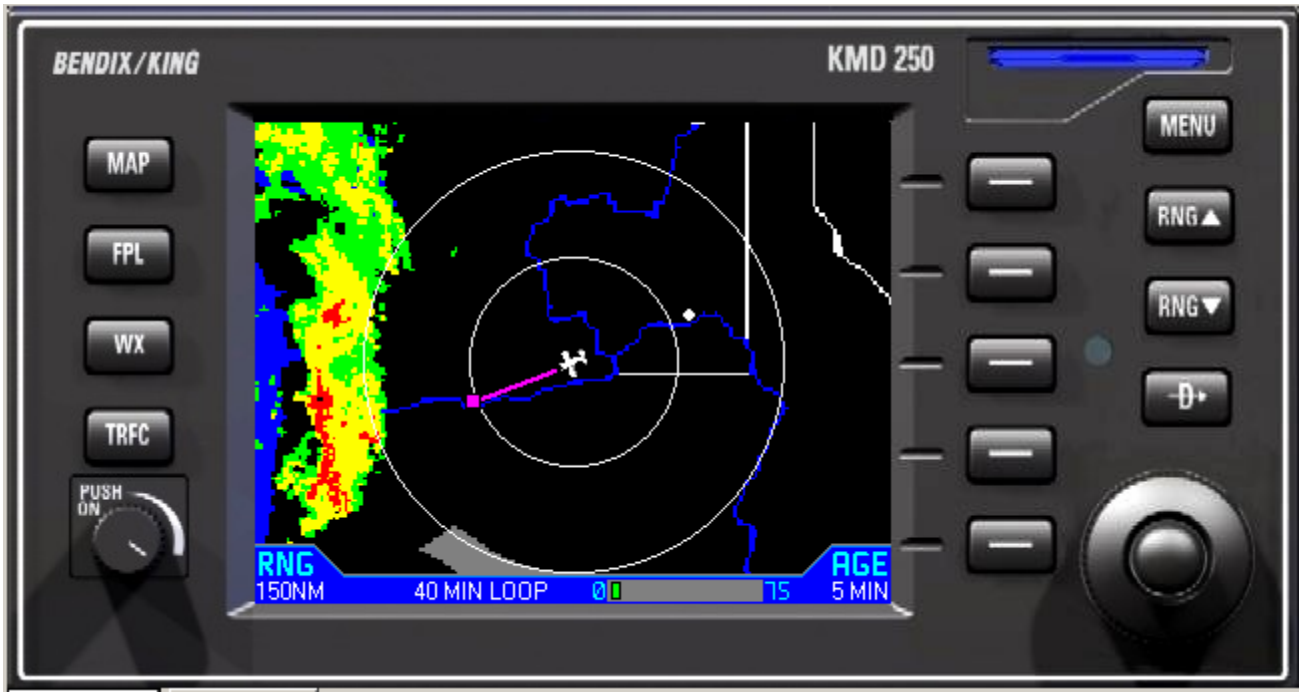
Experiment 1: Non-Animated Image

Aviation Weather Information



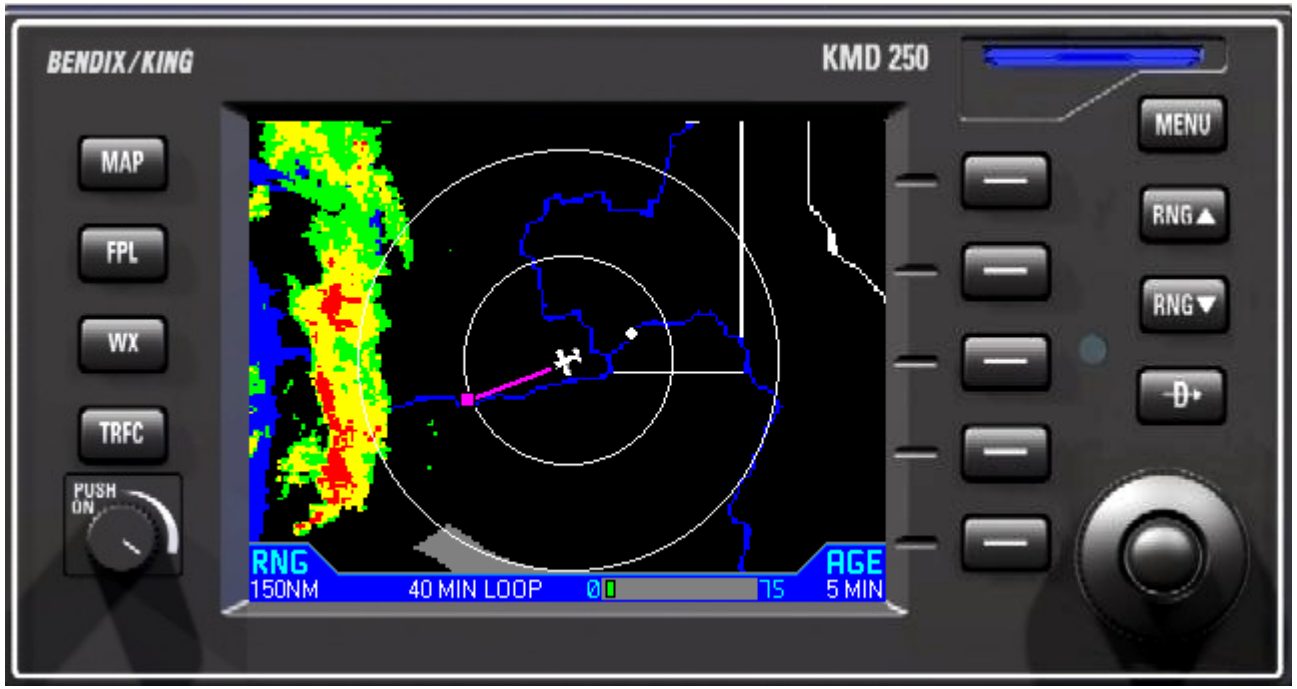
Three-Image Loop: Frame 1

Aviation Weather Information



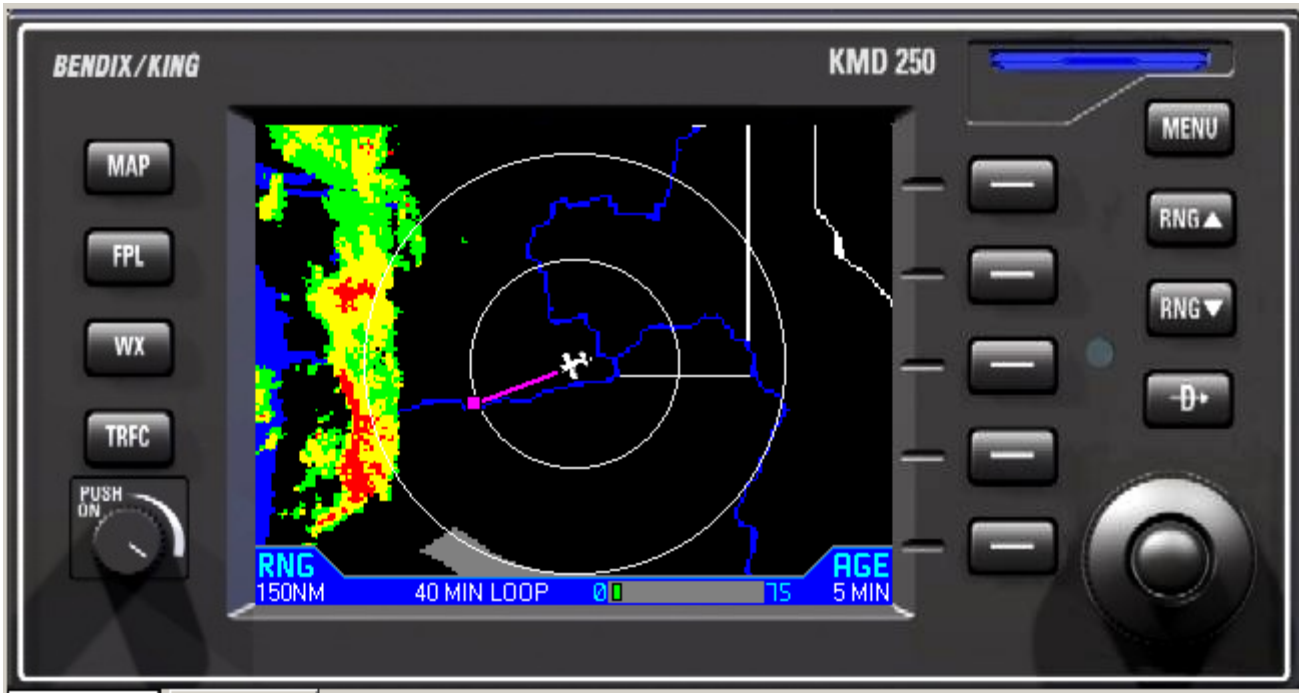
Three-Image Loop: Frame 2

Aviation Weather Information



Three-Image Loop: Frame 3

Aviation Weather Information



Looping Experiment Status

Aviation Weather Information

- **Experiment 1 data collection completed**
  - Loop speed, number of frames, w/ & w/o aircraft looping
  - 65 participants, 10,000+ data points
  - Data analysis ongoing, results expected July 04
- **Design work for experiments 2 & 3 under way**
- **Expected near-term results**
  - Development of aircraft looping concept
  - Guidance for commercial product development

Graphical METAR Presentation

NASA Aviation Safety and Security Program

Weather Accident Prevention Project Review

June 2-4, 2004

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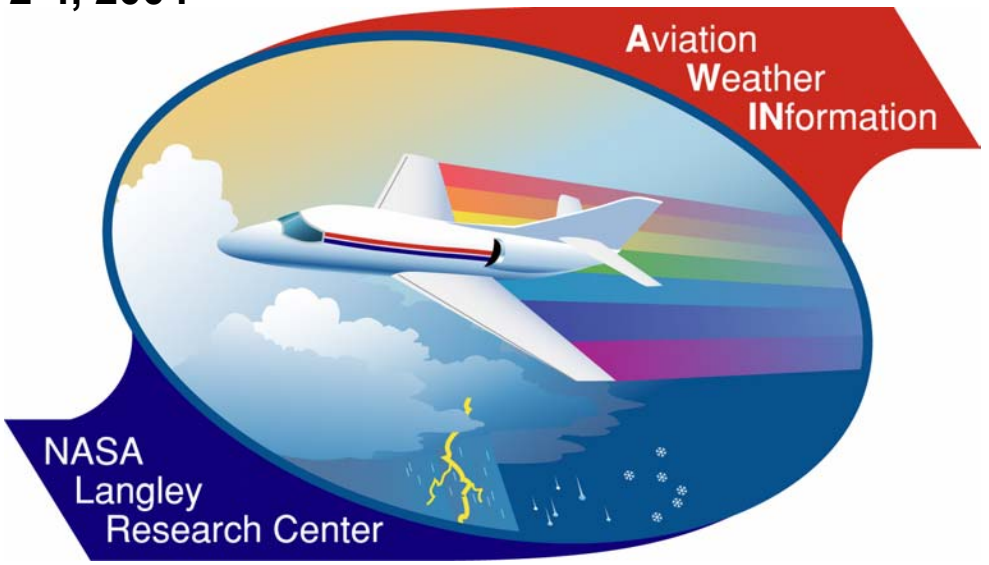
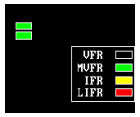


Objectives

- **For 3 systems that show ceiling & visibility**
  - What's best for "at a glance" ceiling/visibility information?
    - Response time, accuracy, confidence in response

- **For 6 existing systems**
  - What current system is preferred, and why?

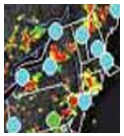


Arnav

Echoflight

Bendix-King

- **Use of METAR information**
  - Time to destination / use of METAR at destination
  - Age of METAR information
  - Hazard perception using METAR information
  - Levels of ceiling & visibility categories preferred


WSI


Merlin


Control Vision

- **Differences between VFR & IFR GA pilots**

Ceiling / Visibility Assessments

NASA Aviation Safety and Security Program

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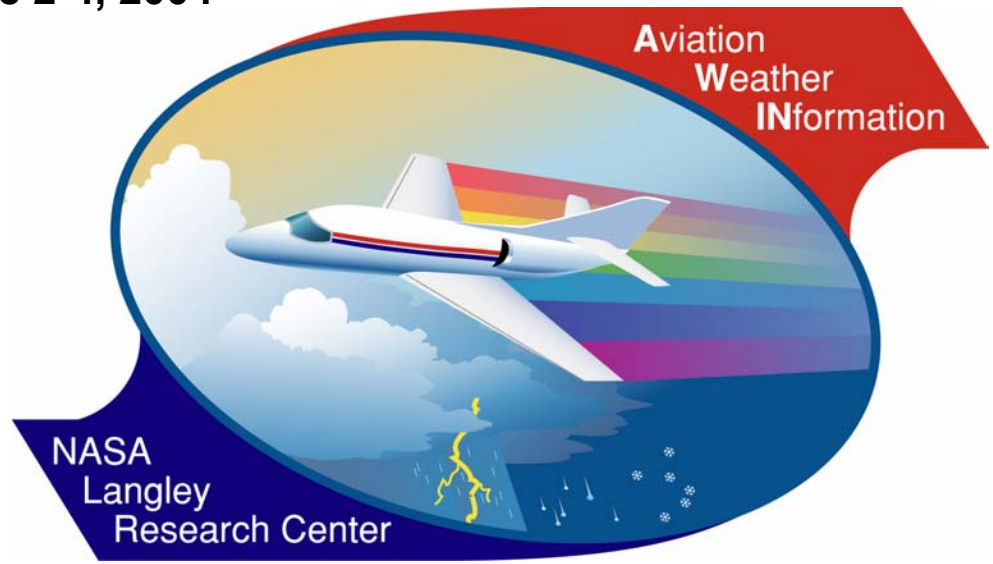


VFR into IMC Efforts

- **Surrounding WEather Estimation Test (SWEET)**
  - *Joe Coyne, Old Dominion University NASA GSRP fellow*
  - Desktop simulation
  - Pilots' ability to assess ceiling & visibility & classify conditions (LIFR, IFR, MVFR, VFR)
- **Imaging techniques for assessing visibility**
  - *Rochester Institute of Technology (RIT) & RTI*
  - Wavelet analysis to identify decreasing visibility and cloud distance
- **In flight assessment of ceiling & visibility**
  - Cloud layers & visibility (ahead, slant) - preparation for SWEET-2
  - Compare pilot assessments with TAMDAR information
  - Obtain video for extension of Imaging Techniques work
- **Ceiling & visibility hazard alerting**
  - TAMDAR information, forecasts/current data comparison

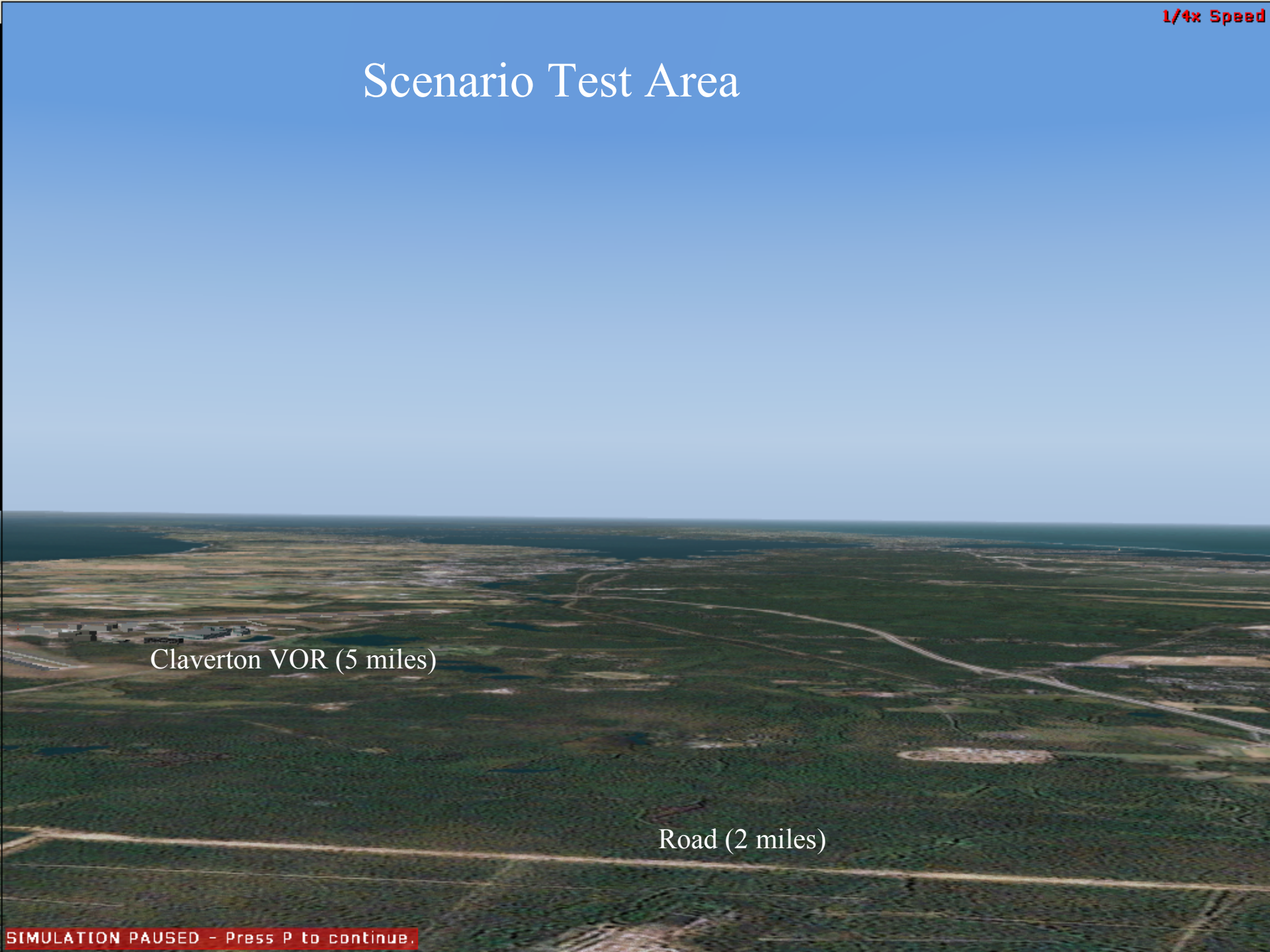
SWEET Experimental Apparatus

Aviation Weather Information

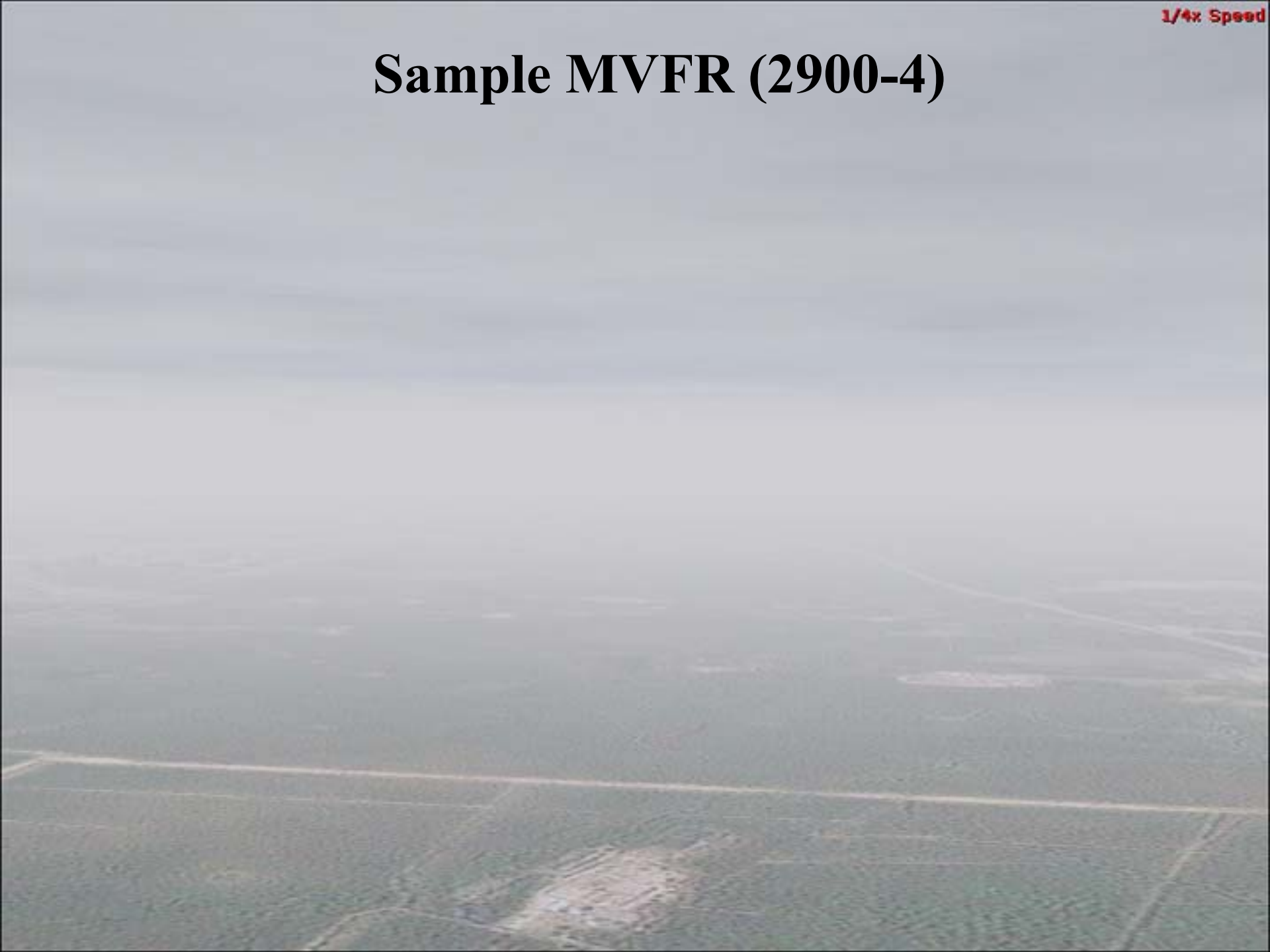
Projected out-window video scene
(repeats until questions answered)

Flight instruments / AWIN

Trial questions


1/4x Speed
Scenario Test Area
Claverton VOR (5 miles)
Road (2 miles)
SIMULATION PAUSED - Press P to continue.

Sample VFR (4500-10)



Sample MVFR (2900-4)

SWEET Analyses

Baseline – without AWIN display

- Varying ceilings and visibilities (4 levels each)
- Both VFR & IFR GA pilots

Effects of AWIN – with graphical METARs

- Varying ceilings and visibilities (3 levels each)
- Both VFR & IFR GA pilots
- Graphical METAR information is: same, worse, better than observed ceiling & visibility

Expected SWEET Results

- **Quantify pilot's ability to assess ceiling and visibility conditions**
- **Compare IFR and VFR pilots' assessment and decisions**
- **Effect of AWIN graphical METAR information**
  - How are conditions interpreted when information is inconsistent?
- **Determine how pilots combine assessments to classify conditions**
  - Does this experiment (with visual scene) replicate compensatory model results found with text information?

COWABUNGA

Characterization Of Weather Acquisition by Users: Next Generation Applications

NASA Aviation Safety and Security Program

Weather Accident Prevention Project Review

June 2-4, 2004

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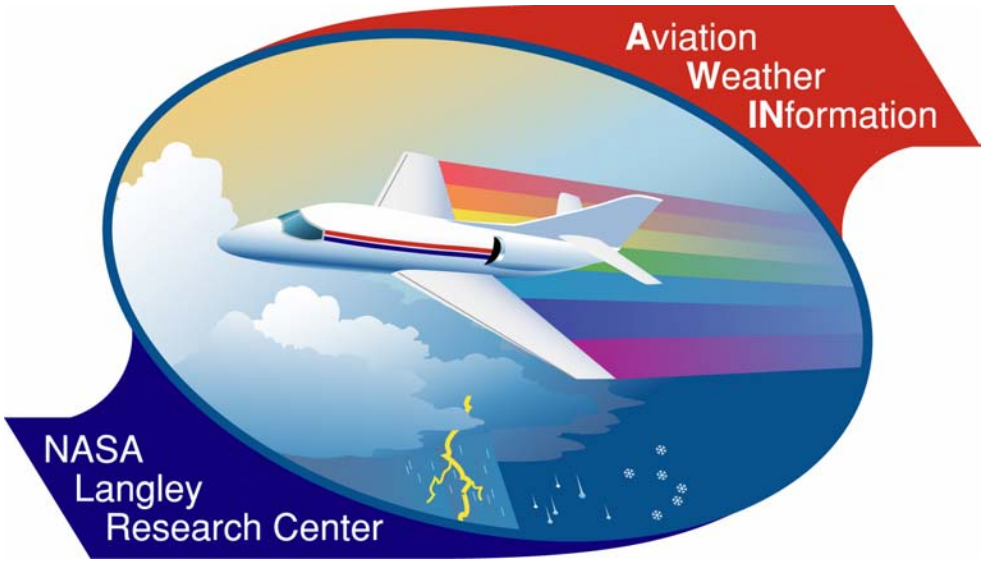


Objectives

Improve next-generation AWIN design guidelines

- **Effect of an AWIN display on pilots' attention distribution**
  - Among flightdeck and window information elements
  - Head-down time & information acquisition within AWIN system
- **Situation awareness**
- **Subjective experiences of an AWIN display**
  - Information utility
  - Usability
  - Workload

Assess new oculometer tool for measuring inflight attention allocation

Airborne Oculometer

- **Special Design Requirements**
  - Robust to high ambient light conditions
  - Resilient to dynamic light conditions
  - Usable with headset, sunglasses used in aviation
  - Comfortable for prolonged use
  - Non-interfering with piloting duties and visual scanning
  - Physically integrated with aircraft (EMI, structures, data collection)
  - Data synched with integrated GPS time

- **Adaptation of Applied Sciences Laboratory 5100 model**
  - Dark pupil method for high ambient lighting
  - Magnetic head tracker (accounts for movement)
  - Integrated video composition (scene + scan path)

AWIN Airborne Oculometer

Aviation Weather Information

AWIN Airborne Oculometer - Integration

Aviation Weather Information

Testing head tracking unit for position, structure, & EMI

Testing integration with pilot sunglasses and headset

Experiment Details

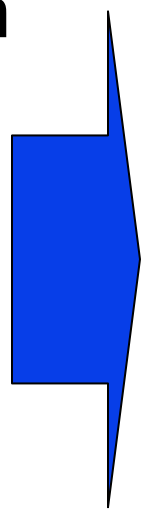
- **Subjects**
  - 10 General Aviation, IFR-current pilots
- **Scenarios**
  - Round trip from/to Langley Field (300nm outbound)
  - Day VMC, enroute portion
  - With / without AWIN system
  - Periodic situation awareness queries/PIREPs
  - Debriefing and usability questionnaires
- **Apparatus**
  - Cessna 206 aircraft
  - WSI InFlight weather information system
  - Airborne oculometer

COWABUNGA Data

- **Attentional cost of an AWIN system**
  - % heads down time in AWIN, %window scan, %instrument scan
- **Information accessed & sequences of access**
  - within AWIN system, and among flight deck information elements
- **Attentional response to AWIN information onset**
- **Information accessed vs. situation awareness reports**
- **Perceived utility and usability**

Results

- **Attention allocation & distribution**
- **Information value & associations**
- **Subjective observations**



formatting

integration/ decluttering

alerting

training

- Oculometer tool tested, validated for inflight use
  - final AWIN milestone flight test

Advanced Weather Avoidance Flight Planner

NASA Aviation Safety and Security Program

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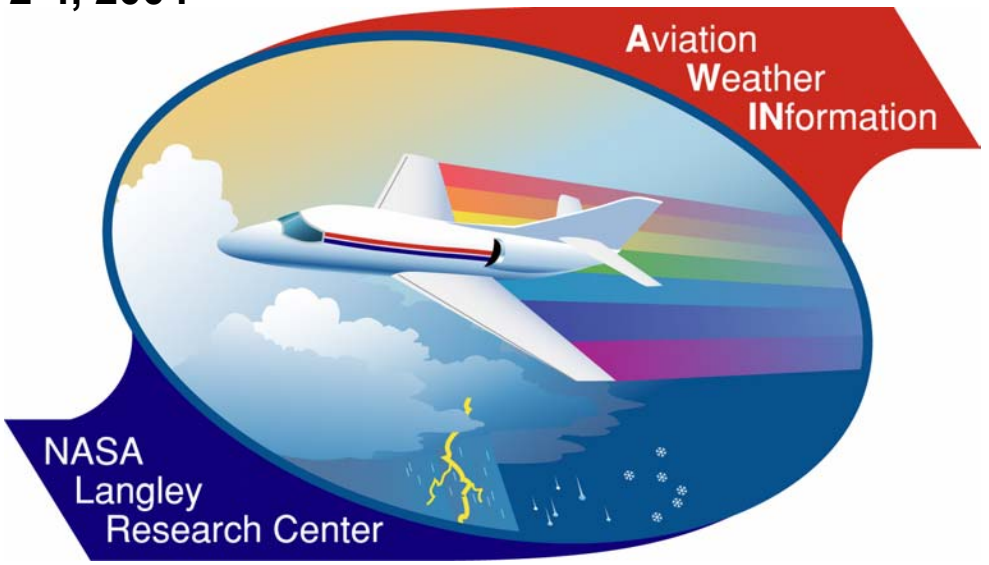

Planner Rationale and Objectives

- **Rationale**
  - Insufficient flight planning is a factor in many general aviation accidents
  - Producing a robust flight plan is time consuming

- **Objectives**
  - Automate route and waypoint generation following AIM guidance
  - Relate safety of flight to:
    - > Pilot capabilities, personal minimums
    - > Aircraft capabilities
    - > Weather hazard avoidance
  - Automate relevant weather report acquisition and analysis

TAMDAR Presentation

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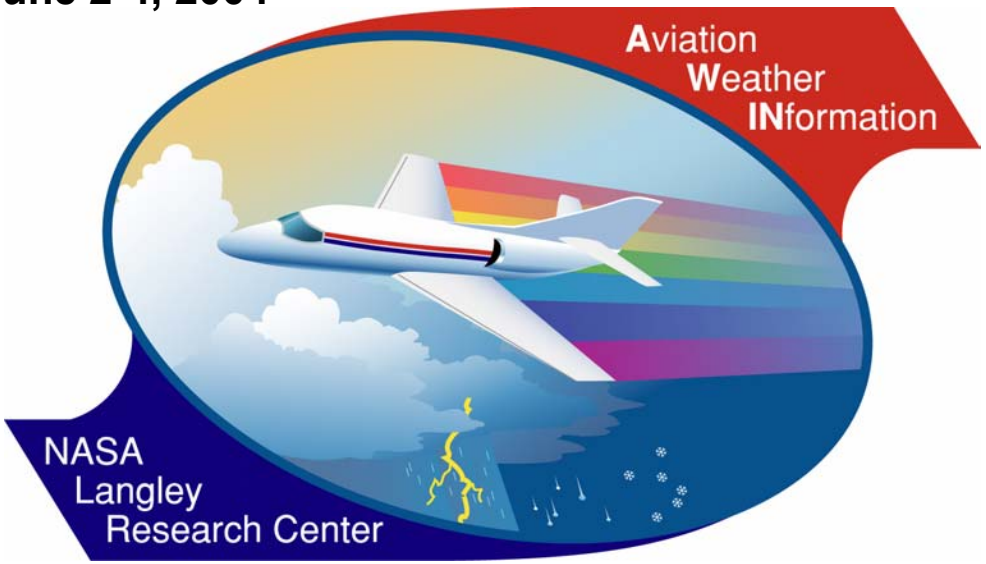

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TAMDAR Display Status

- Workshop 1 – Ownship data, PIREPs, status (May 2003)
- Workshop 2 – Remote ship data, alerting, set-up (June 2003)
- Prototype for MX-20 (Oshkosh, August 2003)
- Identification of platform for C206 experiment (July 2004)

Voice Interface to AWIN System

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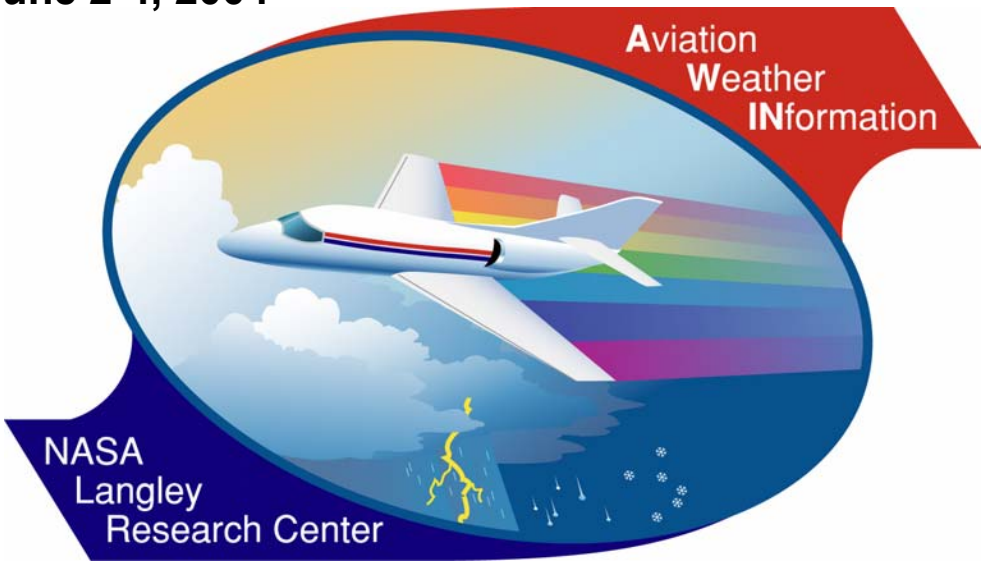

AWIN Voice Interface

- **AWIN interface controls (initially for WSI)**
  - Product presentation
  - De/cluttering strategies
  - Moving map functions (zoom, pan, select)
  - *Consistent integration with other voice interface efforts (e.g., SVS)*

- **PIREP assist**
  - Template format, restricted language
  - Natural language (richer characterization of environment)

GA Cockpit Presentations Summary

Aviation Weather Information

- **Data-linked weather information infrastructures are in place**
- **Much is possible, but little objective design/use guidance exists yet on what works best for pilots**
- **Collective results from AWIN efforts will yield additional guidance for next generation systems**

Information, Not Data